

FORM PTO-1390 (REV 5-93)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER <b>225MU/50870</b>	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371					
INTERNATIONAL APPLICATION NO. PCT/DE00/02621		INTERNATIONAL FILING DATE 5 August 2000		PRIORITY DATE CLAIMED 11 August 1999	
TITLE OF INVENTION BRUSH SEALING RING					
APPLICANT(S) FOR DO/EO/US					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
1.	<input checked="" type="checkbox"/>	This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.			
2.	<input type="checkbox"/>	This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371			
3.	<input checked="" type="checkbox"/>	This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay Examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).			
4.	<input checked="" type="checkbox"/>	A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.			
5.	<input checked="" type="checkbox"/>	A copy of the International Application as filed (35 U.S.C. 371(c)(2)).			
	<input type="checkbox"/>	a.	<input type="checkbox"/>	is transmitted herewith (required only if not transmitted by the International Bureau).	
	<input type="checkbox"/>	b.	<input checked="" type="checkbox"/>	has been transmitted by the International Bureau	
	<input type="checkbox"/>	c.	<input type="checkbox"/>	is not required, as the application was filed in the United States Receiving Office (RO/US)	
6.	<input checked="" type="checkbox"/>	A translation of the International Application into English (35 U.S.C. 371(c)(2)).			
7.	<input checked="" type="checkbox"/>	Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))			
	<input type="checkbox"/>	a.	<input type="checkbox"/>	are transmitted herewith (required only if not transmitted by the International Bureau).	
	<input type="checkbox"/>	b.	<input type="checkbox"/>	have been transmitted by the International Bureau.	
	<input type="checkbox"/>	c.	<input type="checkbox"/>	have not been made; however, the time limit for making such amendments has NOT expired.	
	<input type="checkbox"/>	d.	<input checked="" type="checkbox"/>	have not been made and will not be made.	
8.	<input type="checkbox"/>	A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).			
9.	<input checked="" type="checkbox"/>	An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unexecuted)			
10.	<input checked="" type="checkbox"/>	A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).			
<b>Item 11. to 16. below concern other document(s) or information included:</b>					
11.	<input type="checkbox"/>	An Information Disclosure Statement under 37 CFR 1.97 and 1.98.			
12.	<input type="checkbox"/>	An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.			
13.	<input checked="" type="checkbox"/>	A FIRST preliminary amendment.			
	<input type="checkbox"/>	A SECOND or SUBSEQUENT preliminary amendment.			
14.	<input checked="" type="checkbox"/>	A substitute specification and marked-up copy thereof.			
15.	<input type="checkbox"/>	A change of power of attorney and/or address letter.			
16.	<input checked="" type="checkbox"/>	Other items or information:			
	<input type="checkbox"/>	a. Form PCT/IB/308			
	<input type="checkbox"/>	b. International Preliminary Examination Report w/Annexes; and			
	<input type="checkbox"/>	c. International Search Report			

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.52)  
**70/049230**



**23911**

PATENT TRADEMARK OFFICE

U.S. APPLICATION NO (if known, see 37 CFR 1.5)		INTERNATIONAL APPLICATION NO		ATTORNEY'S DOCKET NUMBER	
10/049230		PCT/DE00/02621		225MU/50870	
17. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):					
Search Report has been prepared by the EPO or JPO				\$ 890.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482)				\$ 710.00	
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))				\$ 740.00	
Neither international preliminary examination fee (37 CFR 1.482) nor International search fee (37 CFR 1.445(a)(2)) paid to USPTO				\$ 1040.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)				\$ 100.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$ 890.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$130.00	
Claims	Number Filed	Number Extra	Rate		
Total Claims	35 - 20 =	15	X \$18.00	\$270.00	
Independent Claims	3 - 3 =	0	X \$84.00	\$	
Multiple dependent claims(s) (if applicable)			+ \$280.00	\$	
TOTAL OF ABOVE CALCULATIONS=				\$1290.00	
Applicant claims Small Entity Status (See 37 CFR §1.27) <input type="checkbox"/> yes <input type="checkbox"/> no. Reduction by 1/2 for filing by small entity, if applicable				\$	
SUBTOTAL =				\$1290.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$1290.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28,3.31). \$40.00 per property +				\$	
TOTAL FEE ENCLOSED =				\$1290.00	
				Amount to be refunded	\$
				Charged	\$
a. <input checked="" type="checkbox"/> A check in the amount of \$1290.00 for the filing fee is enclosed					
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any overpayment to Deposit Account No. 05-1323. A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:				<i>Donald D. Evenson</i>	
Crowell & Moring, L.L.P.				SIGNATURE	
P.O. Box 14300				Donald D. Evenson	
Washington, D.C. 20044-4300				NAME	
Tel. No. (202) 624-2500				26,160	
Fax No. (202) 628-8844				REGISTRATION NUMBER	
				February 11, 2002	
				DATE	

10/049230  
JG13 Rec'd PCT/PTO 11 FEB 2002

Attorney Docket: 225MU/50870  
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: MANFRED DILGER ET AL  
Serial No.: Not Yet Assigned PCT NO.: PCT/DE00/02621  
Filed: February 11, 2002  
Title: BRUSH SEALING RING

PRELIMINARY AMENDMENT

Box PCT  
Commissioner for Patents  
Washington, D.C. 20231

Sir:

Please enter the following amendments to the claims and abstract prior to the examination of the application.

IN THE SPECIFICATION:

A substitute specification and marked-up copy thereof is submitted herewith.

IN THE CLAIMS:

Please cancel all of the claims presently in the application and substitute new claims 8-42 as follows:

8. (new) Brush sealing ring for use as a sealing element between components which can move relative to one another, in particular between a rotor and a stator as an element which is fixed to the stator, having an annular housing and having a multiplicity of aramid fiber-based bristles which are attached within the housing and protrude radially or axially out of the contour of the housing and whose free end faces form tangents with an imaginary, rotationally symmetrical or planar face, the

bristles being composed of sections of strands and/or threads of aramid fibers which are present in a wound arrangement, each section running in a loop shape around a core extending away from it without crossing over in such a way that its two end faces form tangents with the same imaginary face which is spaced apart from the core, and the sections being arranged around the core in a plurality of layers one on top of the other and being secured in a fixed fashion with a clamping section,

wherein the strands and/or threads are composed exclusively of fine, angel hair-like aramid fibers, and

wherein sections of the strands are secured between the core and the clamping section exclusively by means of frictional locking.

9. (new) Brush sealing ring according to Claim 8, wherein the core is shaped from a metal wire with a round cross section and the clamping section is shaped from a metallic round tube which is slotted in the longitudinal direction.

10. (new) Brush sealing ring according to Claim 8, wherein, in addition to their, essentially, radial or axial orientation, the sections have a directional component in the circumferential direction outside the clamping region.

11. (new) Brush sealing ring according to Claim 9, wherein, in addition to their, essentially, radial or axial orientation, the sections have a directional component in the circumferential direction outside the clamping region.

12. (new) Brush sealing ring according to Claim 8, wherein the sections have end faces which are manufactured by mechanical cutting or shearing off, by laser beam cutting, if appropriate with water cooling ("laser micro jet process"), or by means of water jet cutting.

13. (new) Brush sealing ring according to Claim 9, wherein the sections have end faces which are manufactured by mechanical cutting or shearing off, by laser beam cutting, if appropriate with water cooling ("laser micro jet process"), or by means of water jet cutting.

14. (new) Brush sealing ring according to Claim 10, wherein the sections have end faces which are manufactured by mechanical cutting or shearing off, by laser beam cutting, if appropriate with water cooling ("laser micro jet process"), or by means of water jet cutting.
15. (new) Brush sealing ring according to Claim 11, wherein the sections have end faces which are manufactured by mechanical cutting or shearing off, by laser beam cutting, if appropriate with water cooling ("laser micro jet process"), or by means of water jet cutting.
16. (new) Brush sealing ring according to Claim 8, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.
17. (new) Brush sealing ring according to Claim 9, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.
18. (new) Brush sealing ring according to Claim 10, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.
19. (new) Brush sealing ring according to Claim 12, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.
20. (new) Use of a sealing ring according to Claim 8, wherein the sealing ring is configured for sealing predominantly gaseous fluids, including hydrogen.
21. (new) Use of a sealing ring according to Claim 9, wherein the sealing ring is configured for sealing predominantly gaseous fluids, including hydrogen.

22. (new) Use of a sealing ring according to Claim 10, wherein the sealing ring is configured for sealing predominantly gaseous fluids, including hydrogen.
23. (new) Use of a sealing ring according to Claim 12, wherein the sealing ring is configured for sealing predominantly gaseous fluids, including hydrogen.
24. (new) Use of a sealing ring according to Claim 16, wherein the sealing ring is configured for sealing predominantly gaseous fluids, including hydrogen.
25. (new) Use of a sealing ring according to Claim 8, wherein the sealing ring is configured for use in turbo machines of all kinds as well as in electric generators.
26. (new) Use of a sealing ring according to Claim 9, wherein the sealing ring is configured for use in turbo machines of all kinds as well as in electric generators.
27. (new) Use of a sealing ring according to Claim 10, wherein the sealing ring is configured for use in turbo machines of all kinds as well as in electric generators.
28. (new) Use of a sealing ring according to Claim 12, wherein the sealing ring is configured for use in turbo machines of all kinds as well as in electric generators.
29. (new) Use of a sealing ring according to Claim 16, wherein the sealing ring is configured for use in turbo machines of all kinds as well as in electric generators.
30. (new) Use of a sealing ring according to Claim 20, wherein the sealing ring is configured for use in turbo machines of all kinds as well as in electric generators.

31. (new) A bush sealing ring for sealing a space between a rotor and a stator comprising:

an annular housing fixed in use to said stator,

a core carried by the annular housing, and

a plurality of strand sections extending in a loop around the core and extending with end faces forming tangents with an annular face spaced from the core, and

a clamp securing said strand sections to the core,

wherein the strand sections are formed exclusively of fine, angel hair aramid fibers, and

wherein the strand sections are secured between the clamp and the core exclusively by fictional clamping.

32. (new) A brush sealing ring according to Claim 30, wherein the core is shaped from a metal wire with a round cross section and the clamping section is shaped from a metallic round tube which is slotted in the longitudinal direction.

33. (new) A brush sealing ring according to Claim 30, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.

34. (new) A brush sealing ring according to Claim 31, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.

35. (new) A brush sealing ring according to Claim 30, wherein said rotor and stator are part of a turbo machine.

36. (new) A brush sealing ring according to Claim 30, wherein said rotor and stator are part of an electric generator.

37. (new) A method of making a sealing ring for sealing a space between a rotor and a stator, comprising:

fixing an annular seal housing to said stator,

placing a core in said annular seal housing with a plurality of fiber strand sections looped around the core which extend with end faces forming tangents with an annular face spaced from the core to sealing engage the rotor, and

clamping the strand sections to the core,

wherein the strand sections are formed exclusively of fine, angel hair aramid fibers, and

wherein the strand sections are secured between the clamp and the core exclusively by fictional clamping.

38. (new) A method according to Claim 37, wherein the core is shaped from a metal wire with a round cross section and the clamping section is shaped from a metallic round tube which is slotted in the longitudinal direction.

39. (new) A method according to Claim 37, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.



40. (new) A method according to Claim 38, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.

41. (new) A method according to Claim 37, wherein the aramid fibers which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.

42. (new) A method according to Claim 37, wherein said rotor and stator are part of a turbo machine.

**IN THE ABSTRACT:**

Please add an Abstract of the Disclosure submitted herewith on a separate page.

**REMARKS**

Entry of the amendments to the specification, claims and abstract before examination of the application is respectfully requested. These claims patentably define over the art of record.

If there are any questions regarding this Preliminary Amendment or this application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #225MU/50870).

February 11, 2002

Respectfully submitted,



Donald D. Evenson  
Registration No. 26,160

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DDE:tvq

**ABSTRACT OF THE DISCLOSURE**

Brush sealing ring for components which can move relative to one another, has an annular housing and a multiplicity of aramid fiber-based bristles which are attached in said housing and protrude radially or axially out of the contour of the housing. The bristles are composed of sections of aramid fiber strands or threads which are present in a wound arrangement, each section runs in a loop shape around a core and extends away from it without crossing over, its two end faces forming tangents with the same face, and the sections are arranged in a plurality of layers one on top of the other and are secured in a frictional locking fashion to a clamping section.

10/049230  
JG13 Rec'd PCT/PTO 11 FEB 2002

Attorney Docket: 225MU/50870  
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: MANFRED DILGER ET AL  
Serial No.: Not Yet Assigned PCT NO.:PCT/DE00/02621  
Filed: February 11, 2002  
Title: BRUSH SEALING RING

SUBMISSION OF SUBSTITUTE SPECIFICATION

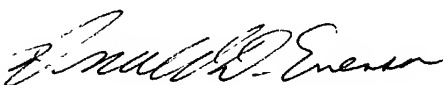
Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

Attached is a Substitute Specification and a marked-up copy of the original specification. I certify that said substitute specification contains no new matter and includes the changes indicated in the marked-up copy of the original specification.

Respectfully submitted,

February 11, 2002

  
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DDE:tvvg

CLEAN SPECIFICATION  
Attorney Docket No: 225MU/50870

## BRUSH SEALING RING

### BACKGROUND AND SUMMARY OF THE INVENTION

[0001] The invention relates to a brush sealing ring for use as a sealing element between two components which can move relative to one another in particular between a rotor and a stator as an element which is fixed to the stator, having an annular housing and having a multiplicity of aramid fiber-based bristles which are attached within the housing and protrude radially or axially out of the contour of the housing and whose free end faces form tangents with an imaginary, rotationally symmetrical or planar face.

[0002] Brush sealing rings of this type can be provided with bristles which protrude radially outwards, radially inwards or in an axially lateral direction. An installed brush sealing ring forms the actual brush seal by interacting with a smooth, wear-resistant component corresponding surface with a preferably circular cylindrical or planar geometry. In order to keep the bristles free of centrifugal forces, the brush sealing rings are generally installed fixed to the stator. In addition to rotating components, such as shafts, oscillating or quasi-static components which do not move very much can also be sealed with

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brushes, such a seal being non-hermetic, i.e. operating with a certain degree of leakage. The media which are to be sealed are preferably gaseous.

**[0003]** DE 3429 708 C1 protects a brush seal whose bristles are embodied as a composite of materials. Here, the core of the bristles is to be spring-elastic, i.e. deformable in a reversibly elastic fashion, and the coating of the bristle is to be a good thermal conductor and to reduce friction and wear. A multiplicity of materials or combinations of materials which may be suitable in this sense are mentioned. Inter alia, reference is made to plastic as a core material or sheath material, and the table at the end of the description specifies Kevlar, i.e. aramid fibers, as a brush core material which can be metallically coated. The overall context, specifically the figures, indicate that here bristles are meant in the sense of straight, separate sections of material which have defined cross sections and which can be handled satisfactorily, for example grasped, bundled, clamped, soldered, adhered, sintered etc.

**[0004]** Anyone familiar with the term “angel hair-like” structure of aramid fibre strands or threads etc. is aware of the fact that it is not possible to fashion them into bristles or brushes according to the abovementioned patent, or it is possible to do so only with an

uneconomically high level of expenditure.

**[0005]** EP 0 211 275 B1 relates to a method including a device for manufacturing a brush seal using winding technology. Here, bristle material in thread form or wire form is wound over two parallel spikes, held with clamping bars and cut between the spikes. The resulting, initially straight brushes are bent to form rings and joined so that continuous brush sealing rings with bristles protruding on one side are obtained. The ends of the bristles can then be machined more precisely to a finished dimension by shortening. The patent is aimed mainly at metal and ceramics as bristle material, i.e. at “wire-like” hard material with a defined cross section. The silicon carbide fibre (SiC fibre) which is of particular interest in this context - in addition to metal - presents problems in that they can no longer be wound around narrow radii in the thickness which is preferred for brushes so that a core (spike) which is greater in cross section and a clamping section which is correspondingly greater in diameter is required. The method protected by the EP Patent has to date been essentially used only for metal brushes.

**[0006]** DE 197 20 649 A1 deals with a brush seal having a special housing geometry which improves the support of the bristles during operation, i.e. when there is a pressure difference, and as a result reduces

the leakage. The loop-like bristle arrangement around a wire core with securing by means of a clamping element is familiar. Such a brush sealing ring can advantageously be fabricated using the method according to EP 0 211 275 B1. DE 197 20 649 A1 does not contain anything specific relating to the bristle material.

**[0007]** In view of the above, the object of the invention is to configure a brush sealing ring with aramid fibre-based bristles, which is distinguished by favourable manufacture, a definite and reproducible brush structure and a satisfactory and predictable sealing behaviour.

**[0008]** This object is achieved by a brush seal of the above noted type characterized by a combination of the following features in particular between a rotor and a stator as an element which is fixed to the stator, having an annular housing and having a multiplicity of aramid fiber-based bristles which are attached within the housing and protrude radially or axially out of the contour of the housing and whose free end faces form tangents with an imaginary, rotationally symmetrical or planar face, the bristles being composed of sections of strands and/or threads of aramid fibers which are present in a wound arrangement, each section running in a loop shape around a core extending away from it without crossing over in such a way that its two end faces form tangents



with the same imaginary face which is spaced apart from the core, and the sections being arranged around the core in a plurality of layers one on top of the other and being secured in a fixed fashion with a clamping section.

**[0009]** Surprisingly, it has been found that the fine “angel hair-like” strands or threads of aramid fibers can reliably be secured and oriented by clamping, i.e. frictional locking. The loop-shaped arrangement around a core gives rise to a particularly low-stress, reliable securing means by virtue of a large “clamping length” per bristle/section in contact with a clamping section which engages around it. An important aspect in terms of fabrication technology is that the bristles are sections of strands or threads which are present in a wound arrangement, because the aramid fibre material to be used can only be handled effectively using winding technology. It is to be noted that a brush of this kind does not have any clearly distinguishable, stiff bristles with defined cross sections but rather resembles a fine hair paintbrush with hair geometries which vary within limits.

**[0010]** Preferred embodiments of the brush sealing ring according to the main claim are characterized in the subclaims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0011]** The invention will be explained in more detail below with reference to the drawing. The figure shows, in a view which is not to scale, a cross section, i.e. an axially radial section, through a brush sealing ring.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0012]** The brush sealing ring 1 has an annular, at least essentially rotationally symmetrical housing 2 as a supporting, protective and also sealing element. For reasons of fabrication, the latter is composed of two parts, a cover plate 3 and a supporting plate 4, which overlap here axially in the upper region and are connected in a positively locking fashion, preferably by means of beading. The longitudinal centre axis X of the brush sealing ring 1 is located here on the side of the housing 2 on which the bristles protrude from said housing 2. The bristles thus protrude regionally inwards towards the centre from the contour of the housing in order to interact with the central, round corresponding component, in particular a rotating shaft, in which case the axis of the corresponding component (not shown here) should be identical to the longitudinal centre axis X. The brush sealing ring could also be structured in such a way that

the bristles protrude radially over its outer circumference in order, for example, to interact with a hollow shaft as a corresponding component. Taking the present view as a point of departure, the longitudinal centre axis would then have to lie above the sectioned housing.

**[0013]** A further embodiment of the brush sealing ring could also be such that the bristles protrude axially out of the housing in a lateral direction and interact with a corresponding component which is planar in the sealing region. Taking the present view as a point of departure, the longitudinal centre axis would then run vertically and lie laterally to the right or left of the housing section.

**[0014]** All these modifications do not have any influence on the essence of the invention.

**[0015]** The actual invention consists here in a structural design of the brush which is as appropriate as possible for the materials. The starting material for the bristles fibers is made of aromatic polyamides, i.e. aramid fibers, which tend to be known under the designation “Kevlar” or “Kevlar fibers”. The fibers are combined to form strands or threads which are available in a wound form. Sections which form the bristles of the brush are made of the strands or threads. Whether one considers such a section,

or only a plurality of sections, as being a “bristle” is optional and ultimately insignificant.

**[0016]** In the case of aramid fibre brushes which exhibit a fine, soft structure, it would perhaps be better to speak of “brush hairs”.

**[0017]** For the sake of clarification, only two sections 5, 6, i.e. “Bristles” are shown in the figure, the thickness of said bristles being an order of magnitude too large in the illustration and in reality tending to be in the region between a few thousandths and a few hundredths of millimetres. The sections 5, 6 are wrapped in the manner of a loop around a round core 11 and extend away from it on both sides without crossing over in such a way that in each case both end faces 7,9 and 8, 10 of each section 5 and 6 form tangents with the same - imaginary - face F which is at least approximately conformal with the surface of the corresponding component, i.e. corresponds here to a - spacial - circular cylindrical face with the longitudinal centre axis X. The slightly bent arrangement of the sections 5, 6 with lateral abutment against the supporting plate 4 reflects the operating conditions with excess pressure on the side of the cover plate 3, i.e. on the left-hand side. The sections 5, 6 are secured to the core 11 in a frictionally locking fashion by means of a C-shaped clamping section 12 which is prestressed by means of elastic cross-sectional

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Attorney Docket No: 225MU/50870

widening and which can be formed from a slotted tube. Outside the clamping region, i.e. from the face F to the part 12, the sections 5, 6 run - in the unloaded state - in an essentially radial direction or in a radial direction and circumferential direction, i.e. with a defined attitude angle (up to approximately 450) in the circumferential direction. Obliquely positioned "bristles" are more pliant in the radial direction, i.e. they compensate better for deviations in position in the corresponding component. However, a rotation of the shaft is permitted only in the oblique direction of the "bristles". A person skilled in the art is familiar with this and there is therefore no need for it to be presented in more detail. The "bristles" are, according to the invention, sections 5, 6 of strands or threads made of aramid fibers which are present in a wound arrangement. According to a method cited at the beginning which is protected by a patent, the strands/threads are wound around two straight cores which are spaced apart in a parallel arrangement and are secured thereto by means of clamping sections. The windings are then displaced axially with respect to one another in order to generate an attitude angle. The windings are then cut centrally between the cores so that two identical, straight brushes, each with a core and clamping section, are produced. These are bent in an annular shape and joined at a joint by welding, soldering, adhering or the like, during which process care has to be taken to ensure that the plastic fibers are not damaged or destroyed

thermally. Inter alia, a strut joint with solder points would be conceivable, in which case heat can be conducted away via the solder contacts. Each annular, coherent brush is integrated into a two-part - or multi-part - housing so that the desired brush sealing ring is obtained. The free, protruding bristle ends can then be machined more precisely to their dimensions (face F).

[0018] The tough, tear-resistant aramid fibers are relatively difficult to cut so that special cutting methods may be necessary. Apart from mechanical cutting, punching, edge-trimming etc., in particular laser beam cutting without and with cooling or water beam cutting without and with abrasive additives are conceivable here.

Mark-up Specification  
Attorney Docket No: 225MU/50870

## BRUSH SEALING RING

### BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates to a brush sealing ring for use as a sealing element between two components which can move relative to one another[, as claimed in the preamble of Patent Claim 1] in particular between a rotor and a stator as an element which is fixed to the stator, having an annular housing and having a multiplicity of aramid fiber-based bristles which are attached within the housing and protrude radially or axially out of the contour of the housing and whose free end faces form tangents with an imaginary, rotationally symmetrical or planar face.

Brush sealing rings of this type can be provided with bristles which protrude radially outwards, radially inwards or in an axially lateral direction. An installed brush sealing ring forms the actual brush seal by interacting with a smooth, wear-resistant component corresponding surface with a preferably circular cylindrical or planar geometry. In order to keep the bristles free of centrifugal forces, the brush sealing rings are generally installed fixed to the stator. In addition to rotating components, such as shafts, oscillating or quasi-static components which do not move very much can also be sealed with brushes, such a seal being non-hermetic,

i.e. operating with a certain degree of leakage. The media which are to be sealed are preferably gaseous.

DE 3429 708 C1 protects a brush seal whose bristles are embodied as a composite of materials. Here, the core of the bristles is to be spring-elastic, i.e. deformable in a reversibly elastic fashion, and the coating of the bristle is to be a good thermal conductor and to reduce friction and wear. A multiplicity of materials or combinations of materials which may be suitable in this sense are mentioned. Inter alia, reference is made to plastic as a core material or sheath material, and the table at the end of the description specifies Kevlar, i.e. aramid fibers, as a brush core material which can be metallically coated. The overall context, specifically the figures, indicate that here bristles are meant in the sense of straight, separate sections of material which have defined cross sections and which can be handled satisfactorily, for example grasped, bundled, clamped, soldered, adhered, sintered etc.

Anyone familiar with the term “angel hair-like” structure of aramid fibre strands or threads etc. is aware of the fact that it is not possible to fashion them into bristles or brushes according to the abovementioned patent, or it is possible to do so only with an uneconomically high level of expenditure.



EP 0 211 275 B1 relates to a method including a device for manufacturing a brush seal using winding technology. Here, bristle material in thread form or wire form is wound over two parallel spikes, held with clamping bars and cut between the spikes. The resulting, initially straight brushes are bent to form rings and joined so that continuous brush sealing rings with bristles protruding on one side are obtained. The ends of the bristles can then be machined more precisely to a finished dimension by shortening. The patent is aimed mainly at metal and ceramics as bristle material, i.e. at "wire-like" hard material with a defined cross section. The silicon carbide fibre (SiC fibre) which is of particular interest in this context - in addition to metal - presents problems in that they can no longer be wound around narrow radii in the thickness which is preferred for brushes so that a core (spike) which is greater in cross section and a clamping section which is correspondingly greater in diameter is required. The method protected by the EP Patent has to date been essentially used only for metal brushes.

DE 197 20 649 A1 deals with a brush seal having a special housing geometry which improves the support of the bristles during operation, i.e. when there is a pressure difference, and as a result reduces the leakage. The loop-like bristle arrangement around a wire core with securing by means of a clamping element is familiar. Such a brush sealing ring can advantageously be fabricated using the method according to EP 0 211 275 B1. DE 197 20 649 A1 does not contain anything

specific relating to the bristle material.

In view of the above, the object of the invention is to configure a brush sealing ring with aramid fibre-based bristles, which is distinguished by favourable manufacture, a definite and reproducible brush structure and a satisfactory and predictable sealing behaviour.

This object is achieved by [means of the combination of features characterized in Claim 1, in conjunction with the genus-forming features in its preamble] a brush seal of the above noted type characterized by a combination of the following features in particular between a rotor and a stator as an element which is fixed to the stator, having an annular housing and having a multiplicity of aramid fiber-based bristles which are attached within the housing and protrude radially or axially out of the contour of the housing and whose free end faces form tangents with an imaginary, rotationally symmetrical or planar face, the bristles being composed of sections of strands and/or threads of aramid fibers which are present in a wound arrangement, each section running in a loop shape around a core extending away from it without crossing over in such a way that its two end faces form tangents with the same imaginary face which is spaced apart from the core, and the sections being arranged around the core in a plurality of layers one on top of the other and being secured in a fixed fashion with a clamping section.

Surprisingly, it has been found that the fine “angel hair-like” strands or threads of aramid fibers can reliably be secured and oriented by clamping, i.e. frictional locking. The loop-shaped arrangement around a core gives rise to a particularly low-stress, reliable securing means by virtue of a large “clamping length” per bristle/section in contact with a clamping section which engages around it. An important aspect in terms of fabrication technology is that the bristles are sections of strands or threads which are present in a wound arrangement, because the aramid fibre material to be used can only be handled effectively using winding technology. It is to be noted that a brush of this kind does not have any clearly distinguishable, stiff bristles with defined cross sections but rather resembles a fine hair paintbrush with hair geometries which vary within limits.

Preferred embodiments of the brush sealing ring according to the main claim are characterized in the subclaims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in more detail below with reference to the drawing. The figure shows, in a view which is not to scale, a cross section, i.e. an axially radial section, through a brush sealing ring.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The brush sealing ring 1 has an annular, at least essentially rotationally symmetrical housing 2 as a supporting, protective and also sealing element. For reasons of fabrication, the latter is composed of two parts, a cover plate 3 and a supporting plate 4, which overlap here axially in the upper region and are connected in a positively locking fashion, preferably by means of beading. The longitudinal centre axis X of the brush sealing ring 1 is located here on the side of the housing 2 on which the bristles protrude from said housing 2. The bristles thus protrude regionally inwards towards the centre from the contour of the housing in order to interact with the central, round corresponding component, in particular a rotating shaft, in which case the axis of the corresponding component (not shown here) should be identical to the longitudinal centre axis X. The brush sealing ring could also be structured in such a way that the bristles protrude radially over its outer circumference in order, for example, to interact with a hollow shaft as a corresponding component. Taking the present view as a point of departure, the longitudinal centre axis would then have to lie above the sectioned housing.

A further embodiment of the brush sealing ring could also be such that the bristles protrude axially out of the housing in a lateral direction and interact with

a corresponding component which is planar in the sealing region. Taking the present view as a point of departure, the longitudinal centre axis would then run vertically and lie laterally to the right or left of the housing section.

All these modifications do not have any influence on the essence of the invention.

The actual invention consists here in a structural design of the brush which is as appropriate as possible for the materials. The starting material for the bristles fibers is made of aromatic polyamides, i.e. aramid fibers, which tend to be known under the designation "Kevlar" or "Kevlar fibers". The fibers are combined to form strands or threads which are available in a wound form. Sections which form the bristles of the brush are made of the strands or threads. Whether one considers such a section, or only a plurality of sections, as being a "bristle" is optional and ultimately insignificant.

In the case of aramid fibre brushes which exhibit a fine, soft structure, it would perhaps be better to speak of "brush hairs".

For the sake of clarification, only two sections 5, 6, i.e. "Bristles" are shown in the figure, the thickness of said bristles being an order of magnitude too large in

the illustration and in reality tending to be in the region between a few thousandths and a few hundredths of millimetres. The sections 5, 6 are wrapped in the manner of a loop around a round core 11 and extend away from it on both sides without crossing over in such a way that in each case both end faces 7,9 and 8, 10 of each section 5 and 6 form tangents with the same - imaginary - face F which is at least approximately conformal with the surface of the corresponding component, i.e. corresponds here to a - spacial - circular cylindrical face with the longitudinal centre axis X. The slightly bent arrangement of the sections 5, 6 with lateral abutment against the supporting plate 4 reflects the operating conditions with excess pressure on the side of the cover plate 3, i.e. on the left-hand side. The sections 5, 6 are secured to the core 11 in a frictionally locking fashion by means of a C-shaped clamping section 12 which is prestressed by means of elastic cross-sectional widening and which can be formed from a slotted tube. Outside the clamping region, i.e. from the face F to the part 12, the sections 5, 6 run - in the unloaded state - in an essentially radial direction or in a radial direction and circumferential direction, i.e. with a defined attitude angle (up to approximately 45°) in the circumferential direction. Obliquely positioned "bristles" are more pliant in the radial direction, i.e. they compensate better for deviations in position in the corresponding component. However, a rotation of the shaft is permitted only in the oblique direction of the "bristles". A person skilled in the art is familiar with this and there is therefore no need for it to be presented in more detail. The "bristles" are, according to the

invention, sections 5, 6 of strands or threads made of aramid fibers which are present in a wound arrangement. According to a method cited at the beginning which is protected by a patent, the strands/threads are wound around two straight cores which are spaced apart in a parallel arrangement and are secured thereto by means of clamping sections. The windings are then displaced axially with respect to one another in order to generate an attitude angle. The windings are then cut centrally between the cores so that two identical, straight brushes, each with a core and clamping section, are produced. These are bent in an annular shape and joined at a joint by welding, soldering, adhering or the like, during which process care has to be taken to ensure that the plastic fibers are not damaged or destroyed thermally. Inter alia, a strut joint with solder points would be conceivable, in which case heat can be conducted away via the solder contacts. Each annular, coherent brush is integrated into a two-part - or multi-part - housing so that the desired brush sealing ring is obtained. The free, protruding bristle ends can then be machined more precisely to their dimensions (face F).

The tough, tear-resistant aramid fibers are relatively difficult to cut so that special cutting methods may be necessary. Apart from mechanical cutting, punching, edge-trimming etc., in particular laser beam cutting without and with cooling or water beam cutting without and with abrasive additives are conceivable here.

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Brush sealing ring

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5 a sealing element between two components which can move  
relative to one another, as claimed in the preamble of  
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metallically coated. The overall context, specifically



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10

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20

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20 towards the centre from the contour of the housing in order to interact with the central, round corresponding component, in particular a rotating shaft, in which case the axis of the corresponding component (not shown here) should be identical to the longitudinal centre axis X.  
25 The brush sealing ring could also be structured in such a way that the bristles protrude radially over its outer circumference in order, for example, to interact with a hollow shaft as a corresponding component. Taking the present view as a point of departure, the longitudinal  
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A further embodiment of the brush sealing ring could also be such that the bristles protrude axially out of the  
35 housing in a lateral direction and interact with a corresponding component which is planar in the sealing

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- 5 -

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The actual invention consists here in a structural design of the brush which is as appropriate as possible for the materials. The starting material for the bristles fibres made of aromatic polyamides, i.e. aramid fibres, which tend to be known under the designation "Kevlar" or "Kevlar fibres". The fibres are combined to form strands or threads which are available in a wound form. Sections which form the bristles of the brush are made of the strands or threads. Whether one considers such a section, or only a plurality of sections, as being a "bristle" is optional and ultimately insignificant.

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- are not damaged or destroyed thermally. Inter alia, a strut joint with solder points would be conceivable, in which case heat can be conducted away via the solder contacts. Each annular, coherent brush is integrated into
- 5 a two-part - or multi-part - housing so that the desired brush sealing ring is obtained. The free, protruding bristle ends can then be machined more precisely to their dimensions (face F).
- 10 The tough, tear-resistant aramid fibres are relatively difficult to cut so that special cutting methods may be necessary. Apart from mechanical cutting, punching, edge-trimming etc., in particular laser beam cutting without and with cooling or water beam cutting without and with
- 15 abrasive additives are conceivable here.

# Patent Claims

1. Brush sealing ring for use as a sealing element  
5 between components which can move relative to one  
another, in particular between a rotor and a stator  
as an element which is fixed to the stator, having  
an annular housing and having a multiplicity of  
10 aramid fibre-based bristles which are attached  
within the housing and protrude radially or axially  
out of the contour of the housing and whose free end  
faces form tangents with an imaginary, rotationally  
symmetrical or planar face, characterized by a  
combination of the following features:  
15 A) the bristles are composed of sections (5, 6) of  
strands and/or threads of aramid fibres which  
are present in a wound arrangement,  
B) each section (5, 6) runs in a loop shape around  
a core (11) extending away from it without  
20 crossing over in such a way that its two end  
faces (7, 9; 8, 10) form tangents with the  
same imaginary face (F) which is spaced apart  
from the core (11), and  
C) the sections (5, 6) are arranged around the  
25 core (11) in a plurality of layers one on top  
of the other and are secured in a frictionally  
locking fashion with a clamping section (12).  
2. Brush sealing ring according to Claim 1,  
30 characterized in that the core (11) is shaped from  
a metal wire with a round cross section and the  
clamping section (12) is shaped from a metallic  
round tube which is slotted in the longitudinal  
direction.  
35 3. Brush sealing ring according to Claim 1 or 2,

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characterized in that, in addition to their, essentially, radial or axial orientation, the sections (5, 6) have a directional component in the circumferential direction outside the clamping region (12).

4. Brush sealing ring according to one or more of Claims 1 to 3, characterized in that the section (5, 6) have end faces (7, 9; 8, 10) which are manufactured by mechanical cutting or shearing off, by laser beam cutting, if appropriate with water cooling ("laser micro jet process"), or by means of water jet cutting.
5. Brush sealing ring according to one or more of Claims 1 to 4, characterized in that the aramid fibres which are used as bristle material correspond in their chemical and physical structure to the Kevlar, Type 49, from DuPont.
6. Brush sealing ring according to one or more of Claims 1 to 5, characterized in that it is configured for sealing predominantly gaseous fluids, including hydrogen.
7. Brush sealing ring according to one or more of Claims 1 to 6, characterized in that it is configured for use in turbo machines of all kinds as well as in electric generators.



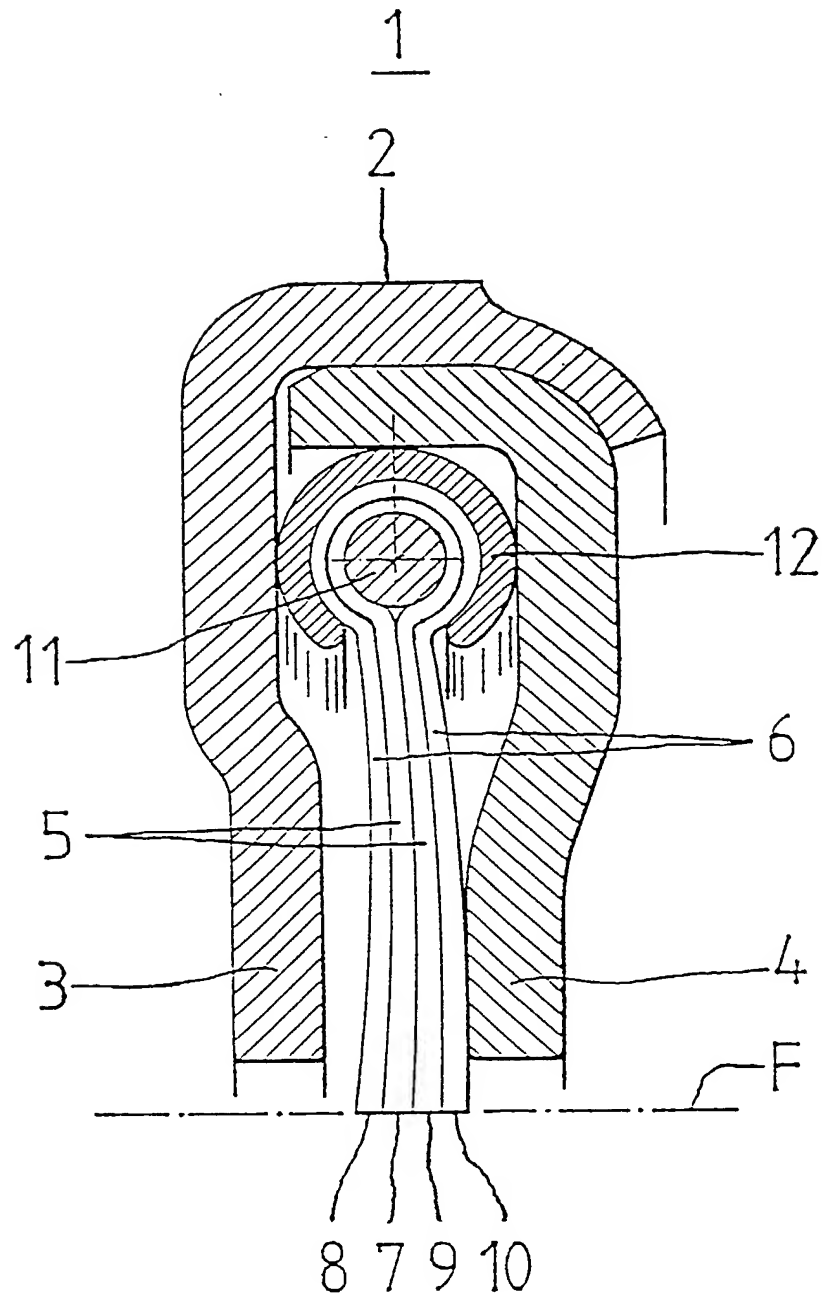
P609410/WO/1

### Abstract

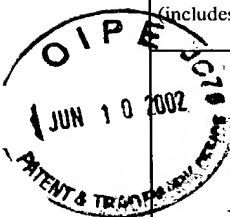
Brush sealing ring for components which can move relative to one another, having an annular housing and having a multiplicity of aramid fibre-based bristles which are attached in said housing and protrude radially or axially out of the contour of the housing.

The bristles are composed of sections of aramid fibre strands or threads which are present in a wound arrangement, each section runs in a loop shape around a core and extends away from it without crossing over, its two end faces forming tangents with the same face, and the sections are arranged in a plurality of layers one on top of the other and are secured in a frictional locking fashion to a clamping section.

(Fig.)



X



**COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY**  
(includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER  
225MU/50870

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

BRUSH SEALING RING

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application  
Serial No. \_\_\_\_\_  
on \_\_\_\_\_  
and was amended  
on \_\_\_\_\_ (if applicable).

☒ was filed as PCT international application  
Number PCT/DE00/02621  
on August 5, 2000  
and was amended under PCT Article 19  
on \_\_\_\_\_ (if applicable)

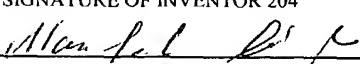
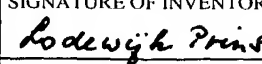
I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations. §1.56(a).

I hereby claim foreign priority benefits under Title 35, United State Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

**PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:**

COUNTRY (if PCT indicate PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	199 37 932.7	11 August 1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

Combined Declaration For Patent Application and Power of Attorney (Continued) (includes Reference to PCT international Applications)				ATTORNEY'S DOCKET NUMBER 225MU/50870	
I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national of PCT international filing date of this application.					
PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120					
U.S. APPLICATIONS			STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED	
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (IF ANY)			
<p>POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)</p> <p style="margin-left: 40px;">Herbert I. Cantor, Reg. No. <u>24,392</u>; James F. McKeown, Reg. No. <u>25,406</u>, Donald D. Evenson, Reg. No. <u>26,160</u>; Joseph D. Evans, Reg. No. <u>26,269</u>; Gary R. Edwards, Reg. No. <u>31,824</u>; and Jeffrey D. Sanok, Reg. No. <u>32,169</u></p>					
Send Correspondence to:			Direct Telephone Calls to: (name and telephone number)		
<u>Crowell &amp; Moring, L.L.P.</u> <u>1200 G Street, N.W., Suite 700</u> <u>Washington, D.C. 20005</u>			<u>(202) 628-8800</u>		
100 201	FULL NAME OF INVENTOR	FAMILY NAME <u>DILGER</u>	FIRST GIVEN NAME <u>Manfred</u>	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY <u>Emmering</u> <span style="margin-left: 20px;"><u>DEU</u></span>	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP <u>German</u>	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS <u>Bgm -Eberl-Strasse 15</u>	CITY <u>Emmering</u>	STATE & ZIP CODE/COUNTRY <u>82275, Germany</u>	
202	FULL NAME OF INVENTOR	FAMILY NAME <u>PRINS</u>	FIRST GIVEN NAME <u>Lodewijk</u>	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY <u>Eurasburg</u> <span style="margin-left: 20px;"><u>DEU</u></span>	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP <u>German</u>	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS <u>Im Tal 22</u>	CITY <u>Eurasburg</u>	STATE & ZIP CODE/COUNTRY <u>D-86495, Germany</u>	
203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
<p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.</p>					
SIGNATURE OF INVENTOR 204 		SIGNATURE OF INVENTOR 205 		SIGNATURE OF INVENTOR 206	
DATE <u>27.07.02</u>		Date <u>04.03.02</u>		DATE	